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ABSTRACT

The United States Training and Employment Service General Aptitude Test Battery (GATB), first published in 1947, has been included in a continuing program of research to validate the tests against success in many different occupations. The GATB consists of 12 tests which measure nine aptitudes: General Learning Ability; Verbal Aptitude; Numerical Aptitude; Spatial Aptitude; Form Perception; Clerical Perception; Motor Coordination; Finger Dexterity; and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, and a standard deviation of 20. Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, when combined, predict job performance. Cutting scores are set only for those aptitudes which aid in predicting the performance of the job duties of the experimental sample. The GATB norms described are appropriate only for jobs with content similar to that shown in the job description presented in this report. A description of the validation sample is included. (AG)

ED 061311

TECHNICAL REPORT

ON

STANDARDIZATION OF THE GENERAL APTITUDE TEST BATTERY

FOR

Power-Plant Operator (any ind.) I 952.782

5-106

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EDUCATION & WELFARE
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U. S. Employment Service in
Cooperation with
Pennsylvania State Employment Service

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STANDARDIZATION OF THE GENERAL APTITUDE TEST BATTERY
FOR
. Power-Plant Operator (any ind.) I 952.782-030

S-106

Summary

The General Aptitude Test Battery, B-1001, was administered in May and November 1952 to 54 male senior students who were enrolled in the course for Power-Plant Operators at the Williamson Free School of Mechanical Trades, Delaware County, Pennsylvania. Two criteria were used: final grades in Trade Practice and final grades in Trade Theory. On the basis of mean scores, standard deviations, correlations with the criteria, job analysis data and their combined selective efficiency, Aptitudes S-Spatial Aptitude, F-Finger Dexterity and M-Manual Dexterity were selected for inclusion in the test norms.

GATB Norms for Power-Plant Operator (any ind.) I 952.782 S-106

Table I shows, for B-1001 and B-1002, the minimum acceptable score for each aptitude included in the test norms for Power-Plant Operator (any ind.) I 952.782.

TABLE I

Minimum Acceptable Scores on B-1001 and B-1002 for S-106

B-1001			B-1002		
Aptitude	Tests	Minimum Acceptable Aptitude Score	Aptitude	Tests	Minimum Acceptable Aptitude Score
S	CB-1-F CB-1-H	90	S	Part 3	85
F	CB-1-O CB-1-P	85	F	Part 11 Part 12	80
M	CB-1-M CB-1-N	80	M	Part 9 Part 10	80

Effectiveness of Norms

The data in Table IV indicate that 10 of the 16 poor students, or 62 percent of them, did not achieve the minimum scores established as cutting scores on the recommended test norms. Moreover, 34 of the 40 students who made qualifying test scores, or 85 percent, were good students.

TECHNICAL REPORT

I. Problem

This study was conducted to determine the best combination of aptitudes and minimum scores to be used as norms on the General Aptitude Test Battery for the occupation of Power-Plant Operator (any ind.) I 952.782

II. Sample

In May and November 1952, the General Aptitude Test Battery, B-1001, was administered to a total sample of 60 male students who were enrolled as Power-Plant Operators at the Williamson Free School of Mechanical Trades, Delaware County, Pennsylvania. Of the 60 students tested, six left school before completing the course. This resulted in a final sample of 54 students who were graduated from the school.

Upon application to the school, the prospective student is required to submit a transcript of his school record together with a report of a physical examination. If these are satisfactory, the candidate is notified to appear for examination. This examination consists of standard mental and mechanical aptitude tests. The results of these tests are used to select a number of boys to be interviewed by a committee of the Board of Trustees who make the final selections for admittance to the school.

Table II shows the means, standard deviations, ranges, and Pearson product-moment correlations with the criteria for age and education.

TABLE II

Means (M), Standard Deviations (σ), Ranges, Pearson Product-Moment Correlations with the Criterion of Final Grades in Trade Practice (r_1), and Pearson Product-Moment Correlations with the Criterion of Final Grades in Trade Theory (r_2) for Age and Education

Power-Plant Operator (any ind.) I 952.782
N = 54

	M	σ	Range	r_1	r_2
Age (years)	18.1	1.1	16-21	..371**	-.095
Education (years)	10.7	1.0	8-12	.280	.341*

** Significant at the .01 level
* Significant at the .05 level

A significant negative relationship was found between age and final grades in Trade Practice. However, this did not warrant correcting the criterion for age. Education shows a significant positive relationship with final grades in Trade Theory. None of the obtained correlation coefficients is high. The data in Table II indicate that the sample is suitable for test development purposes with respect to age and education.

Job Description

Job Title: Power-Plant Operator (Any Ind.) I 952.782-030

Job Summary: Operates and maintains a power plant consisting of steam boilers, steam engines, air compressors, generators, motors, turbines, pumps and diesel engines. Analyzes fuels, gases and water in order to make proper determinations for efficient operation. Installs and repairs piping systems and related fixtures conducting flow of water, steam, petroleum, air and sewage. Conditions water by filtering, testing and adding neutralizing chemicals, in order to purify water for drinking and bathing. Installs, connects and wires electrical generators and motors to switch boards, panels and electrical circuits so that equipment will function properly and in accordance with specifications.

Work Performed: Operates two 100 H.P. fire tube boilers and one 212 H.P. water tube boiler by setting various controls and regulating the mechanical stokers delivering coal to the furnaces in order to build up a steam flow of about 100 lbs. to the square inch. Sees that sufficient coal is in the hoppers of the worm drive stoker and the ram drive stoker and gives directions to fireman about checking hoppers for refilling. Reads, adjusts and balances the controls including the meter, furnace draft gauge, up draft gauge, boiler pressure gauge and blower pressure gauge in order to establish proper automatic mechanical operation. Sets the feed water regulator for proper boiler water intake by reading gauges and adjusting valves. Tests the flue gases by collecting a sample of flue air with an aspirator and running it through a testing unit to determine chemical analysis of gas and then using this analysis to determine proper combustion adjustments for the furnace. Performs repair work on furnaces, boilers, stokers, blowers and pipes, with the aid of helpers whenever necessary, by disassembling equipment and installing new parts, then reassembling and testing the equipment.

Operates two reciprocating steam engines, each of 75 K.W. capacity, and one steam turbine of 25 K.W. capacity to generate electric power both alternating and direct currents. Sets governors to control speed and pressure, sets rheostats to control current and opens steam valves to start engines. Observes operation for short period in order to make certain all mechanical controls, such as, governor triping mechanism, relief valves, traps and steam separator are functioning properly and that engine is safe to leave in operation for an indefinite period. Assembles and disassembles engines for repair and maintenance, performing all work in this respect with the exception of actual motor repair. Checks the cooling system and steam condensers by looking for leaks or blocks and for the proper flow.

Operates five full Diesel engines and one semi-Diesel engine by opening fuel feed valve and pressing the button of the battery starter. Checks governors, and sets operating speed, sees that the Diesel oil daily operating tank is filled and that the engine fuel pumps are functioning properly, observes operation for a short time and then leaves the engines to operate mechanically for the day. Makes all repairs and adjustments, disassembles and assembles, performs or has helper perform regular disassembly cleaning operations on radiators, air intakes, filters, etc., in order to maintain efficient operation.

Operates 6 reciprocating steam pumps and 6 motor driven centrifugal pumps by opening steam valves or throwing a motor switch for the purpose of pumping boiler feed water, well water, fire water, reservoir water, condensed steam and hot water supply. Performs general repair and maintenance including adjustment of stroke, belts and new packing in order that pumps may perform efficiently.

Operates two motor driven compressors of 50 C.F.M. capacity, started by throwing a switch, that produce compressed air for pressure air cleaning of furnaces, boilers, flues, pipes and air storage for miscellaneous work, such as, spray painting. Repairs and maintains the compressors, checks valves and pressure dials so that they are always in good working order.

Installs and repairs piping systems conducting flow of water, steam, petroleum, air, sewage and related fixtures. Cuts, bends, threads, bolts, reams and fits pipe from 1/8" to 6" diameter by using pipe saws, wrenches, reamers and threaders in order to connect pipe to equipment and fixtures. Lays out and measures, selects proper joints, traps, drains, gaskets and size and type of pipe for installation of steam and hot water heating systems, sewage disposal system, plumbing system, pumping system and for the equipment in the power plant.

Conditions water by filtering, testing and adding neutralizing chemicals in order to purify water for use in boilers and for drinking and bathing. Makes extensive analysis, using laboratory equipment and various reagents, precipitating and neutralizing chemicals and makes calculations for graphs, charts and records in order to make determinations. Operates chlorinators and lime feeders for the purification of drinking water.

Installs, connects and wires electrical generators and motors to switch boards, panels and electrical circuits so that equipment will function properly and in accordance with specifications. Installs and maintains outside distribution lines for high voltage, outside lighting and building lighting of low voltage following the National Electric Code for installation specifications. Disassembles, repairs and assembles switchboxes, junction boxes, transformers, circuit breakers, electrical outlets and electrical hardware, using hand tools and small power tools to connect wires by screws, clamps, solder or patent terminals.

Course Description

First Year - Practice

Fireman's Helper:
Cleaning, firing, tending pumps.
Engine Room Helper:
Cleaning and polishing, taking and entering log readings, lubrication of engines and pumps, operation of pumps, operating switchboard.
Maintenance and Repair:
Boiler cleaning, pipe cutting, threading and fitting, minor plumbing and electrical repair.

Second Year - Practice

Firing (In Charge of Plant):
Blowing tubes, changing gauge glasses, stoker and hand firing, operation of feed, water, heater, pumps, etc.
In Charge of Engine Room:
Operating steam engines, parallelling, generators, operating water system, operating Diesel engines, operating compressors.
Construction and Maintenance:
Pipe fitting, laying out piping, valves and traps, bibbs, flush tanks, etc.; plumbing (except lead work), pumps, stokers, compressors, pipe insulation, adjusting engine bearings, motor inspection, electric circuit trouble shooting, rigging.

Theory

Practical heat, power plant equipment, refrigeration, air conditioning, meters, use of graphs, safety.

Third Year - Practice

Operating Power Plant (as in Second Year):
Construction and Maintenance:
Repairs to engines, refrigeration system repairs, motor inspection, motor repairs, circuit trouble shooting.
Construction and Maintenance Projects:
Wiring, motor tests and repairs, engine repairs, Diesel engine overhaul, Diesel engine testing, engine indicating, planning heating systems, planning lighting systems, use of meters, calculating daily records, water softening and filtration, refrigeration, flue gas analysis, coal analysis, boiler tests, valve setting operation of alternators. Starting, synchronizing, etc., operation of mercury arc rectifier, operation of transformers, analysis of A.C. circuits for inductance, capacitance, power factor, etc., gauge testing.

Theory

Electricity:
Fundamentals, calculations, equipment, and practice, electronics, including such subjects as voltaic electricity, electric heating, electro-chemical effects, lighting, electro-magnetism, D.C. motors and generators, A.C. generators, A.C. principles, single polyphase motors, rectifiers, power factor correction, meters.
Internal Combusionn Engines:
Heat cycles, Otto cycle engines, Diesel cycle engines, Hesselman engines, starting, cooling, fuels, lubricants, etc.
Meters and Records
Safety
Industrial Relations, Attitude of Employer and Employee
Power Plant Economics:
How to calculate costs, how to estimate savings

IV. Experimental Battery

All of the tests of the GATB, B-1001, were administered to the sample group,

V. Criterion

Two sets of criterion measures were used in this study, Trade Practice grades and Trade Theory grades. The trade practice criterion consisted of the final grades in the course of Trade Practice; the trade theory criterion consisted of the final grades in the course of Trade Theory. These courses were selected as criteria because they seemed most pertinent to the job of Power-Plant Operator I.

A Pearson product-moment correlation of .74 was obtained between the two measures, which indicates that there is substantial agreement between the two criteria. Both criteria were used for validation purposes. The distribution of the final grades in Trade Practice ranged from 78 to 88 with a mean of 84.3 and a standard deviation of 2.3; the distribution of the final grades in Trade Theory ranged from 76 to 88 with a mean of 83.2 and a standard deviation of 2.9.

VI. Statistical and Qualitative Analysis

Table III shows the means, standard deviations and Pearson product-moment correlations with the criteria for the aptitudes of the GATB. The means and standard deviations of the aptitudes are comparable to general working population norms with a mean of 100 and a standard deviation of 20.

TABLE III

Means (M), Standard Deviations (σ), and Pearson Product-Moment Correlations with the Criteria of Final Grades in Trade Practice (r_1) and Final Grades in Trade Theory (r_2) for the Aptitudes of the GATB

Power-Plant Operator (any ind.) I 952.782
N = 54

Aptitudes	M	σ	r_1	r_2
G-Intelligence	111.1	11.1	.265	.450**
V-Verbal Aptitude	94.8	8.6	.007	.222
N-Numerical Aptitude	110.6	13.5	.287*	.349**
S-Spatial Aptitude	117.8	17.1	.238	.332*
P-Form Perception	113.1	16.1	.157	.271*
Q-Clerical Perception	94.9	13.6	.301*	.472**
A-Aiming	100.5	15.1	.223	.314*
T-Motor Speed	95.9	17.1	.215	.300*
F-Finger Dexterity	103.9	18.2	.183	.371**
M-Manual Dexterity	98.3	16.9	.444**	.484**

** Significant at the .01 level
* Significant at the .05 level

The statistical results were interpreted in the light of the course and job analysis data. The course and job analysis data indicated that the following aptitudes measured by the GATB appear to be important for this occupation:

Intelligence (G) - required in learning and understanding the fundamentals of the courses in Power-Plant Operator; in making correct analyses of fuels, gasses and water; and in planning operations to maintain a power plant.

Numerical Aptitude (N) - required for all phases of work done by the Powerhouse Engineer which involve measuring and making computations necessary for operations such as fitting pipes to specifications; adjusting and balancing the controls, meters, furnace draft gauge, up draft gauge, boiler pressure gauge and blower pressure gauge; laying out and measuring proper joints, traps and drains for installation.

Spatial Aptitude (S) and Form Perception (P) - required in performing such duties as assembling and disassembling engines for repair, in installing new parts, and in installing, connecting and wiring electrical generators and meters to switchboards, panels and electrical circuits.

Finger Dexterity (F) and Manual Dexterity (M) - required in using hand tools and small power tools, in performing such duties as repair work on furnaces, boilers, stokers, blowers and pipes and in assembling and disassembling operations.

The highest mean scores, in descending order of magnitude, were obtained for Aptitudes S, P, G and N, respectively. All of the aptitudes have standard deviations of less than 20, with Aptitude V exhibiting the smallest standard deviation. When N = 54, correlations of .348 and .268 are significant at the .01 level and the .05 level, respectively. Aptitude M correlates significantly with the trade practice criterion at the .01 level and Aptitudes N and Q correlate significantly with the trade practice criterion at the .05 level. Aptitudes G, N, Q, F and M correlate significantly with the trade theory criterion at the .01 level, and Aptitudes S, P, A and T correlate significantly with the trade theory criterion at the .05 level.

Aptitudes G, N, S, P, F and M were considered for inclusion in the test norms on the basis of the qualitative and quantitative factors cited above: all of these aptitudes appear to be important in terms of the course and job analysis data; Aptitudes S, P, G and N, in that order respectively, have the highest mean scores for this sample; all of these aptitudes show significant correlations with the trade theory criterion; Aptitudes N and M show significant correlations with the trade practice criterion. Tetrachoric correlations with the dichotomized criterion were computed for several sets of trial norms consisting of various combinations of Aptitudes G, N, S, P, F and M and appropriate cutting scores. The best selective efficiency was obtained with a combination of Aptitudes S, F and M. Therefore, these three aptitudes were selected for inclusion in the test norms.

The cutting score for Aptitude S was set at one standard deviation below the mean, rounded to the nearest five-point score level and then adjusted 10 points downward to effect better selective efficiency. The cutting scores for Aptitudes F and M were set at one standard deviation below their respective mean scores and rounded to the nearest five-point score levels. Setting cutting scores at these levels yielded the best selective efficiency for the norms and resulted in cutting scores of 90, 85 and 80 for Aptitudes S, F and M, respectively.

Aptitudes G, N and P were considered for inclusion in the test norms on the basis of the qualitative and quantitative evidence of significance cited above. However, these aptitudes failed to differentiate effectively between the high and low criterion groups and, therefore, tended to decrease the selective efficiency of norms which included Aptitudes S, F and M. In view of this, none of these aptitudes was included in the test norms. Aptitudes Q, A and T showed significant correlations with the criterion but were not considered for inclusion in the test norms because they did not appear to be important on the basis of job analysis data.

VII. Predictive Validity of Norms

In order to compute the tetrachoric correlation coefficient between the norms and the criteria and apply the Chi Square test, the two criteria, final grades in Trade Theory and final grades in Trade Practice were used to establish a dichotomized multiple-hurdle criterion. The critical scores were set at one-half standard deviation below the mean of each criterion; this resulted in a critical score of 82 on final grades in Trade Theory and a critical score of 83 on final grades in Trade Practice. A student had to equal or exceed both cutting scores in order to be placed in the high criterion group. Application of these cutting scores placed 16 of the 54 students, or 30 percent of them, in the low criterion group.

Table IV shows the relationship between test norms consisting of Aptitudes S, F and M with minimum scores of 90, 85 and 80, respectively, and the dichotomized multiple-hurdle criterion for Power-Plant Operator I. Students in the high criterion group have been designated as "good students" and those in the low criterion group as "poor students."

TABLE IV

Relationship between Test Norms Consisting of Aptitudes S, F and M with Critical Scores of 90, 85 and 80, Respectively, and the Criterion for Power-Plant Operator (any ind.) I 952.782

N = 54

	Non-Qualifying Test Scores	Qualifying Test Scores	Total
Good Students	4	34	38
Poor Students	10	6	16
Total	14	40	54

$r_{tet} = .79$ $\qquad$ $X^2 = 13.246$

$\sigma_{r_{tet}} = .24$ $\qquad$ $P/2 < .0005$

The data in the above table indicate a significant relationship between the test norms and the criterion for this sample.

VIII. Conclusions

On the basis of mean scores, correlations with the criteria, course and job analysis data and their combined selective efficiency, Aptitudes S, F and M with minimum scores of 90, 85 and 80, respectively, are recommended as B-1001 norms for the occupation of Power-Plant Operator I 952.782. The equivalent B-1002 norms consist of S-85, F-80 and M-80.

IX. Determination of Occupational Aptitude Pattern

When the specific test norms for an occupation include three aptitudes, only those occupational aptitude patterns which include the same three aptitudes with cutting scores that are within 10 points of the cutting scores established for the specific norms are considered for that occupation. The only one of the existing 22 occupational aptitude patterns which meets these criteria for this study is OAP-14, which consists of S-85, F-95 and M-90 for B-1001. The selective efficiency of OAP-14 for this sample was determined by means of the tetrachoric correlation technique. A tetrachoric correlation of .58 with a standard error of .23 was obtained, which indicates a significant relationship between OAP-14 and the criterion for the experimental sample. The proportion of the sample screened out by OAP-14 was .56, which is within the required range of .10 to .60. Therefore, it is recommended that OAP-14 be used in counseling for the occupation of Power-Plant Operator (any ind.) I 952.782